TRANSMISS1ON ELECTRON MICROSCOPY OF $AL_xGA_{1-x}N$/SIC MULTILAYER STRUCTURES

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The potential of wide-band-gap 111-V nitrides as solar-blind ultraviolet sensors and light emitters has prompted an increasing amount of work recently, including the fabrication of the first UV sensors from as-deposited single crystal GaN[1]. We have used high resolution transmission electron microscopy (TEM) to study the microstructure of two novel developments of wide-band-gap III-V nitrides: the growth of ultra-short period GaN/AlN superlattices (digital alloys); and the incorporation of SiC layers into $Al_xGa_{1-x}N$ structures, B y varying the relative periods in a GaN/AlN superlattice, it should be possible to tailor the band gap of the composite to lie between the elemental values of 365nm for GaN and 200nm for AIN. The group IV semiconductor, SiC, has a close lattice match (< 370) to $Al_xGa_{1-x}N$ for growth on the basal plane. Demonstration of epitaxial growth for $Al_xGa_{1-x}N$/SiC multi] ayers could enable an extension of direct band-gap material towards the visible.

The superlattice samples were grown by low-pressure metalorganic chemical-vapor deposition (MOCVD) using a unique switched atomic-layer-epitaxy (SALE) procedure (as first used by Dapkus et al. for GaAs[2]). GaN was grown on the basal-plane sapphire substrates above a thin AIN layer, which has been found to maximize the crystalline quality of the GaN film. A series of $(GaN)_n(AlN)_m$ superlattices ($n \times m$ where $n, m \leq 6$) were subsequently grown by SALE. Investigation of SiC overgrowth on nitrides was pursued using MOCVD growth on an AIN layer which was in turn deposited on either basal plane sapphire or 6H-SiC substrates. nigh resolution TEM of cross-sections of these structures was performed in a Topcon 002B TEM operating at 200kV with a point-to-point resolution of 0.1 8nm.

TEM samples can be readily prepared in one of two orientations - with the foil normal along ci t her 1100 or 1120. These two directions give complimentary information about the structure due to the different reflections that contribute to the image. in order to obtain structural information, as many reflections as possible should contribute to the image. This is obtained with the 1120 zone-axis. However it is the 0002 reflection which conveys the chemical information, its intensity being dependant on the group 111 material present. Hence to maximise the chemical contrast, the 0002 alone should be used to produce the image. This is most nearly achieved with a 1100 foil normal. A line profile across such an image can unambiguously identify the atomic layering of the superlattice.

MOCVD growth of SiC on AIN on sapphire has shown poor quality as determined by structure images from the TEM. However TEM analysis of growth of SiC on AlN on 6-H SiC shows that initial epitaxy of 3C-SiC is possible. However repeated twinning of the SiC about the basal and inclined planes does occur and beyond about 10nm of SiC growth, crystallinity and surface morphology are greatly degraded, This thickness, though, is sufficient to allow for the possible incorporation of SiC layers in a short period superlattice structure.

References

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2. S. P. Denbaars, C. A. Beyler and P. D. Dapkus Appl. Phys. Lett. 53 (1 988) 1509

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